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[0009]

[Means for solving the Problems and Effect thereof] To achieve the aforesaid object, according to claim 1 of the present invention, there is provided a machining-related information generating apparatus, which automatically generates machining-related information including tool path data indicative of tool traveling paths and cutting conditions and other machining-related data to be used in an NC machine tool, the apparatus being characterized by including: a process/machining model data generating section which extracts at least characteristic data indicative of three-dimensional configurational characteristics of a product from product configuration data generated by CAD, then generates process data indicative of machining processes and machining areas for the respective machining processes on the basis of the extracted characteristic data, and generates stock blank data and machining model data indicative of machining models for the respective machining processes; a process/machining model data storage section for storing therein the characteristic data, the process data indicative of the machining processes and the machining areas, the stock blank data, and the machining model data prepared by the process/machining model data generating section; a tool database storing therein tool data related to tools; a machining condition database storing therein machining condition data indicative of

cutting conditions according to stock blank materials and tool materials and machining methods according to characteristic configurations; a machining-related information generating section which generates tool path data indicative of tools to be used in the respective machining processes, cutting conditions to be employed in the respective machining processes, machining methods to be employed in the respective machining processes, and tool traveling paths to be employed in the respective machining processes on the basis of the process data, the stock blank data, and the machining model data stored in the process/machining model data storage section, the tool data stored in the tool database, and the machining condition data stored in the machining condition database, then generates virtual workpiece configuration data indicative of workpiece configurations to be obtained after completion of the respective machining processes, and generates machining operation information data indicative of machining operation information on the basis of the process data, the stock blank data, the tool path data, and the virtual workpiece configuration data thus generated; a machining-related information storage section for storing therein the data generated by the machining-related information generating section; and output means for outputting the data stored in the machining-related information storage section to an outside.

[0010]

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In the machining-related information generating apparatus according to the present invention, firstly, the process/machining model data generating section extracts only the configuration data required for the generation of the tool path data from product design data generated by the CAD by excluding data such as indicative of dimension lines unnecessary for the generation of the tool path data, and then extracts at least the characteristic data indicative of the three-dimensional configurational characteristics of the product from the extracted configuration data. Note that the three-dimensional configurational characteristics herein indicate how the product is three-dimensionally configured, e.g., whether the product has a round portion, a rectangular portion, a cylindrical portion, a prismatic portion, a convex surface, or a concave surface.

[0011]

Next, the process data indicative of the machining processes and the machining areas for the respective machining processes are generated on the basis of the extracted characteristic data. More specifically, the machining areas are defined as corresponding to the respective characteristic configurations, and then machining processes (e.g., rough machining, semi-finish machining or finish machining) are assigned to the respective machining areas. Alternatively, areas to be subjected to machining with the use of the same tool are regarded as a single machining area, and a

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machining process (e.g., rough machining, semi-finish machining or finish machining) is assigned to the machining area. Further, the stock blank data indicative of the stock blank configuration, and the machining model data indicative of the machining model configurations after completion of the respective machining processes are generated on the basis of the configuration data of the product. Note that for determination of the stock blank configuration and the machining model configurations, finishing allowances in the respective machining processes are sequentially offset from a final product configuration. Then, the characteristic data, the process data, the stock blank data, and the machining model data are stored in the process/machining model data storage section.

[0012]

Next, the machining-related information generating section generates the tool path data indicative of the tools to be used in the respective machining processes, the cutting conditions to be employed in the respective machining processes, the machining methods to be employed in the respective machining processes, the tool traveling paths to be employed in the respective machining processes, and the like on the basis of the process data, the stock blank data and the machining model data stored in the process/machining model data storage section, and the tool data stored in the tool database and the machining condition data stored

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in the machining condition database. The machining methods are herein intended to include machining modes such as contour line machining, scanning line machining, circular interpolation, linear interpolation, and cutting directions, a feed pitch for repetitive machining in a predetermined machining cycle, and a machining sequence for machining in the respective machining areas.

[0013]

Further, the virtual workpiece configuration data indicative of the workpiece configurations to be obtained after the completion of the respective machining processes are generated, and the machining operation information data indicative of the machining operation information is generated on the basis of the process data and the stock blank data generated in the process/machining model data generating section, the tool path data, and the virtual workpiece configuration data. Note that the machining operation information is herein intended to include at least one or more selected from the group consisting of tool information required for a preparatory operation, information indicative of whether a cutting fluid is used, and machining-related information such as cutting conditions, estimated machining times, tool wear amounts, tool life expectancies, and a workpiece configuration to be obtained after completion of machining.

[0014]

The tool path data and the machining operation information

data thus generated are stored as the machining-related information in the machining-related information storage section and, as required, outputted through the output means to the outside on an image basis or a text basis in a displayed form or a printed form, or on an electronic data basis.

[0015]

As described, according to the present invention, there is no need for an operator to input the data of the characteristic configurations of the product and the data of the machining methods indicative of the tools to be used and the cutting conditions for the generation of the tool path data, so that the data input time is obviated. Therefore, the tool path data can speedily be generated, thereby effectively speeding up the machining of the product. Further, human errors in the data input can be eliminated, thereby preventing production of defective products and damages to jigs and tools that may otherwise occur due to the input errors. The effect of the present invention is particularly remarkable in the case of machining for production of a uniquely customized product such as a mold.

[0016]

Note that the tool path data is herein intended to include all information required for operating the NC machine tool such as data indicative of tool traveling paths, tool rotation speeds, and tool feeding speeds, and means data which serves as a base for

generating motion data required for executing an NC machining program and for directly driving a servo mechanism of the NC machine tool or the like.

[0017]

Further, since the machining-related information including the information required for the preparatory operation for the machining can automatically be generated, human errors in a worksheet formulating operation can be prevented to streamline the worksheet formulating operation. By utilizing the machining-related information thus generated, the preparatory operation for the machining can easily be performed in a shorter time. Further, a machining time can be estimated, so that an optimum time slot (daytime or night-time) can be selected for the machining. In other words, if a machining operation is expected to be completed in a short time, the machining operation may be performed during an operator-attended operation period and, after the completion of the machining operation, the operator can perform the next workpiece machining operation or the next preparatory operation. Thus, the productivity can be improved. On the other hand, if a machining operation is expected to require much time, the machining operation may be performed during a nighttime non-attended operation period. Further, the number of the tools required for the machining and the machining time can be estimated, thereby making it possible to preliminarily calculate costs for the machining of the workpiece.

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Therefore, cost estimation can promptly be provided.

[0018]

Note that, according to the invention as recited in claim 2, the machining-related information generating apparatus may further include an NC machining program generating section which converts the tool path data generated by the machining-related information generating section into an NC machining program, which is in turn outputted to the outside. Further, according to the invention as recited in claim 3, the machining-related information generating apparatus may further include a motion data generating section which converts the tool path data into motion data, which is in turn outputted to the outside. According to the invention as recited in claim 2 or 3, the machining program or the motion data thus generated can directly be inputted on-line to a numerical controller of the NC machine tool, or inputted to the numerical controller with the use of a recording medium such as a floppy disk (registered trademark). Thus, according to the invention as recited in claims 2 and 3, the generation of the tool path data can be carried out with no link-up to the NC machine tool, i.e., on an off-line basis, so that the utilization factor of the NC machine tool can be increased. Note that the motion data herein means data required for directly driving the servo mechanism or the like of the NC machine tool.

[0019]

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On the other hand, according to the invention as recited in claim 4 of the present invention, the tool path data thus generated may immediately be implemented and processed for the machining.

Note that the invention according to claim 4 provides a numerical controller for controlling an operation of an NC machine tool on the basis of tool path data indicative of tool traveling paths and cutting conditions, the controller being characterized by including: a machining-related information generating apparatus as recited in any of claims 1 through 3; and a process executing section which executes a process sequence on the basis of tool path data generated by the machining-related information generating section to control the operation of the NC machine tool.